

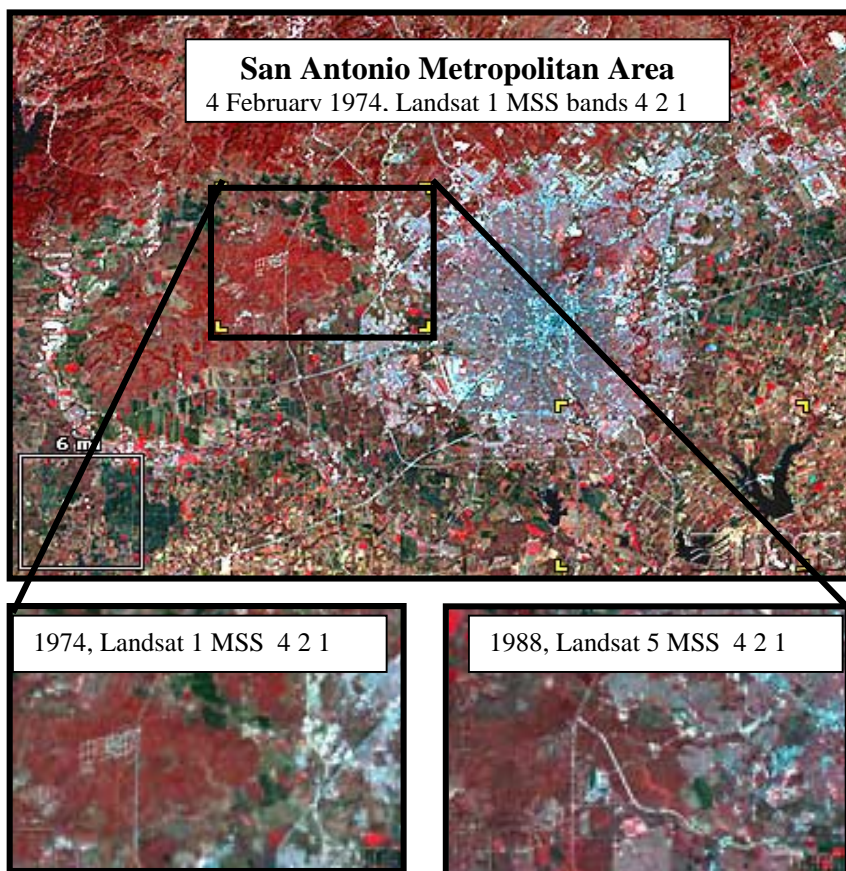


LAND COVER CHANGE DETECTION: STUDYING VEGETATION FROM SPACE

Purpose

To create the Normalized Difference Vegetation Index (NDVI) images necessary to complete the vegetation change detection lesson.

Overview



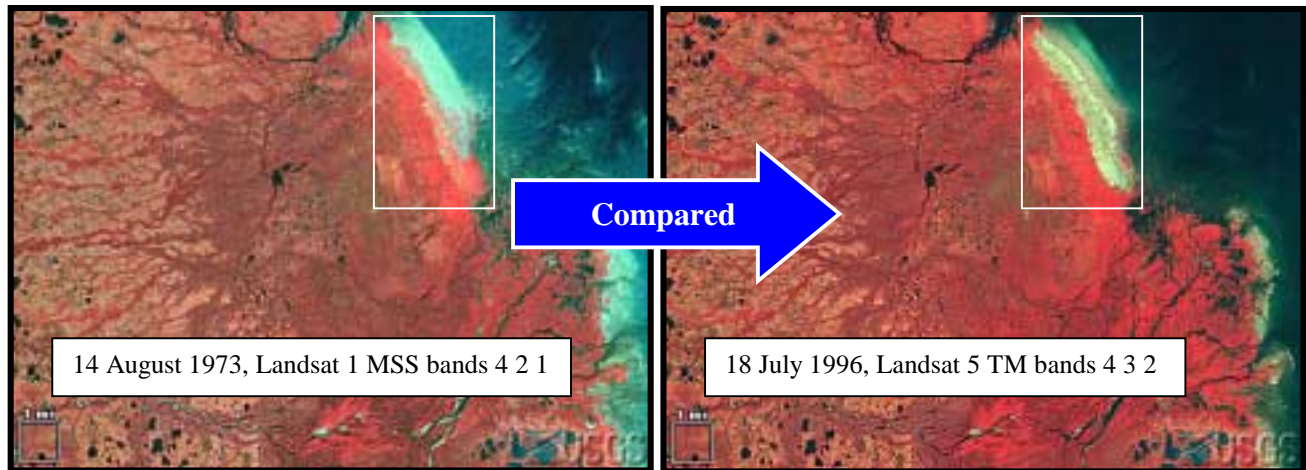
In this project, students will work with Landsat data and MultiSpec image processing software as they determine the extent and types of land cover change that have occurred in the community over a seventeen year period.

SVS figure 1. In the detailed images urban sprawl in San Antonio, Texas is visible between 1974 and 1988.

Pronounced urban/suburban expansion is visible on the west edge of the city. In this set of color composite images vegetation is red and urban areas are gray and blue. [USGS Earth shots](http://www.usgs.gov/Earthshots/),

The growth of cities and suburbs changes the vegetative land cover in an area. Schools, housing developments, asphalt, and athletic fields replace meadows, forests and farmlands. In arid areas, deserts become green with irrigation-supported lawns and golf courses. Changes in the pattern (distribution) and type of vegetation can be characterized through the use of Landsat data. Figure 1 illustrates some of the vegetative land cover changes that take place in an expanding urban area. (see SVS figure 1)

Not all land cover change is a result of urban expansion. Many natural processes can significantly alter vegetation patterns in an area. The [Knife River Delta](#) in Canada (SVS Figure 2) illustrates an example of one of these natural processes. These images show vegetation loss along the shoreline of Hudson Bay in central Canada. The ground cover was eaten bare by growing numbers of snow geese. In these Landsat images, red signifies vegetation and water appears green to dark green to black. In the first image, taken August 14th 1973, the highlighted patch of shoreline is densely vegetated. In the second image, taken July 18th 1996, a large portion of the same area is no longer covered with vegetation. The bright green patch of land in the second image was eaten bare by snow geese.

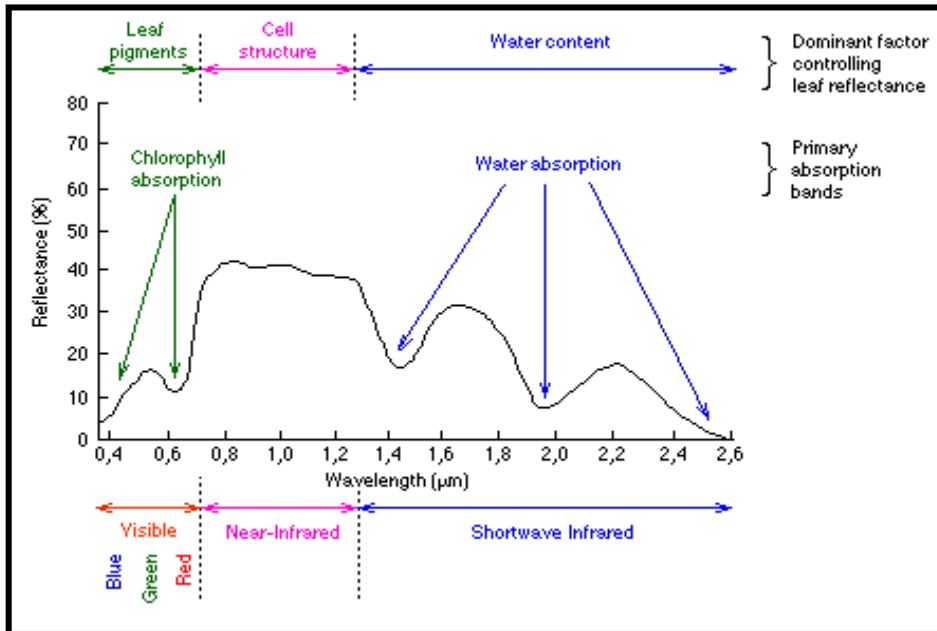


SVS Figure 2. Bookmark www.usgs.gov/Earthshots for *Earthshots*, 5th ed., 14 August 1999, from the [EROS Data Center](#) of the [U.S. Geological Survey](#), a bureau of the [U.S. Department of the Interior](#). Knife River Delta, Canada 1973, 1996, visited 4-25-00

BACKGROUND INFORMATION

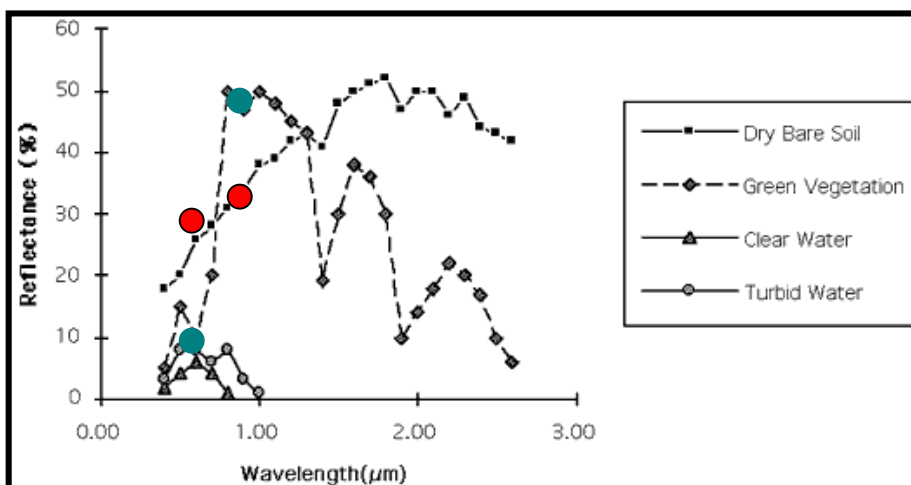
SATELLITE IMAGE VEGETATION INDICES

Landsat images can be manipulated to better distinguish plants from other types of land cover through the use of imaging processing software. This manipulation is possible due to the way plants reflect light back into space. Plants have a unique spectral signature that offers a reflected light “fingerprint.” The most unique portion of the



SVS graph 1. Typical spectral response characteristics of green vegetation, Brigitte Leblon, Ph.D., <http://research.umbc.edu/~tbenja1/leblon/frame9.html>, visited 2-14-00

reflectance (10%). Most red light (90%) is absorbed by the plant’s chlorophyll. The lower the red values reflectance, the higher the chlorophyll content. (see graph 1) The near infrared (NIR) band or channel records the reflectance of NIR by the leaves’ cell



SVS graph 2. Spectral signatures of different substrates compared. **GLOBE Teacher's Guide** [Implementation Guide: Remote sensing](#), visited 2-23-00

spectral signature or “fingerprint” of vegetation or a typical plant is seen in graph 1. Note that the largest contrast in reflectance is between the red (in the visible wavelengths) and the near infrared. The red band or channel records a low percentage of

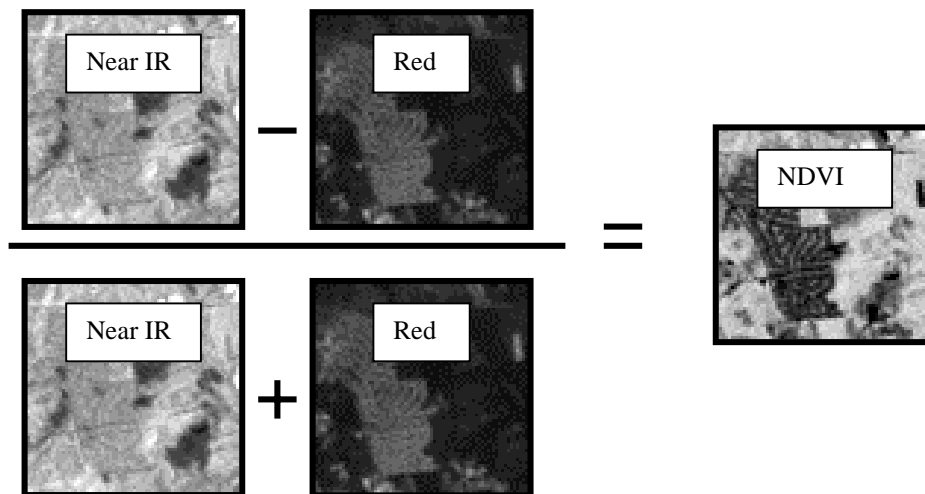
reflectance of a plant’s NIR is high it shows more intense growth (Sabins, 1997). This contrast makes it possible to create an image that separates vegetative land cover from

nonvegetative land cover.

In graph 2, the reflectance difference is apparent if you compare the spectral differences of dry bare soil ● and green vegetation ● between the 0.6µm and 0.8 µm wavelengths. The difference in reflection (%) is much greater for green vegetation than dry bare soil. A quick way to identify vegetation in a spectral signature graph is to look at the slope of the line between red (0.6µm) and NIR (0.8µm). A steep positive slope between these points will often indicate the presence of vegetation.

Vegetation indices are used to isolate vegetation's presence and photosynthetic activity from other types of land cover. The vegetation index that is used in this project is the Normalized Difference Vegetation Index (NDVI), which is defined by an algebraic formula:

$$\frac{\text{near IR band} - \text{red band}}{\text{near IR band} + \text{red band}} = \text{NDVI}$$



The NDVI index is “preferred to the simple index [or band ratio e.g. IR/R] for global vegetation monitoring because the NDVI helps compensate for changing illuminations conditions, surface slope, aspect, and other extraneous factors” (Lillesand and Kiefer, 1994). This is an important aspect to consider. When the Landsat satellite acquires images of one season in different years some of the “illuminations conditions” may be different. The NDVI index improves the comparison between the two or more images.

NDVI pixel values created using the above algebraic formula range from -1 to 1. The values for vegetation range from a low of 0.05 to a high of 0.66 (Lillesand and Kiefer, 1994). Clouds, snow water and bright nonvegetated surfaces have a NDVI value of less than zero. The highest value in the vegetation range represents the maximum “greenness.”(Lillesand and Kiefer, 1994) Greenness is a measure of plant biomass that is actively producing chlorophyll ([GreenReport](#), 1998). The vegetation value range used in the NDVI indices illustrates the state of health and or development of vegetation. High values usually shown as dark green areas (in MultiSpec they are white) represent areas of healthy, abundant vegetation in a mature state of development. Lower values, usually

depicted with lighter green (in MultiSpec they are gray and black), show areas with emerging or lesser amounts of vegetation (GreenReport, 1998).

The Mathematics of NDVI

In order to understand the math formula used to create an NDVI image, you must know the reflectance values for each channel of a given pixel. You can use MultiSpec to find and compare the reflectance values of two pixels. Once an image is opened, click on a chosen pixel and pull down the “processor” menu. Select the “list data” function and a window titled “SET LIST DATA SPECIFICATIONS” will appear. The coordinates of the selected area (pixel) will be automatically entered. Check the “include line and column” box in the options section of the window and click on OK.

SET LIST DATA SPECIFICATIONS

Area(s)

☒ Image Area

Selected Area

Line Start End Interval

213 213 1

Column 127 127 1

Channels: All

Options

List channels in: Rows

☒ Include line and column values

☐ Graph data values

Output results to

☒ Text window

☐ Disk file

Cancel OK

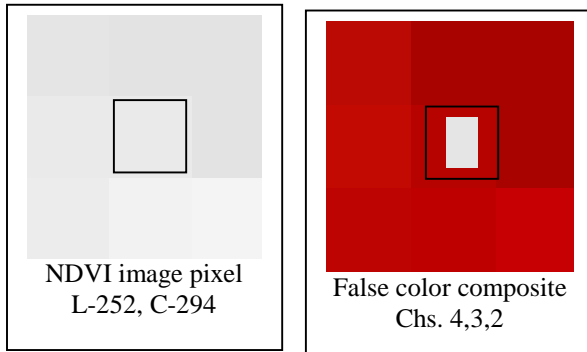
Next, pull down the “window” menu and select “text output”. A list of pixel image data values will appear at the end of the text output window. Each channel’s grayscale value will be displayed separately. MultiSpec uses a 0-255 grayscale, a value of 0 is displayed as black and a value of 255 is displayed as white, with varying shades of gray in between. In the example below two different pixels have been selected for comparison, one from a forested area and the other from an urban/residential area.

Forest land cover pixel

QASJUL97 Multispectral Image Data Values

Using the data below, specifically the red and the near infrared wavelength channel data, it is possible to see how an NDVI image is created.

Line	Col	Blue (Ch1)	Green (Ch2)	Red (Ch3)	NIR (Ch4)	MIR (Ch5)	Thermal (Ch6)	MIR (Ch7)
252	204	121	43	42	120	64	126	19



$$\frac{\text{near IR band} - \text{red band}}{\text{near IR band} + \text{red band}} = \text{NDVI} \quad \text{or} \quad \frac{\text{channel 4} - \text{channel 3}}{\text{channel 4} + \text{channel 3}} = \text{NDVI}$$

$$\frac{4 - 3}{4 + 3} = \text{NDVI} \rightarrow \frac{120 - 42}{120 + 42} = \text{NDVI} \rightarrow \frac{78}{162} = 0.48 \text{ (which is the NDVI value)}$$

97 NDVI Multispectral Image Data Values

Line	Col	NDVI value (Ch 1)
252	204	0.48 *255=122.4⇒123

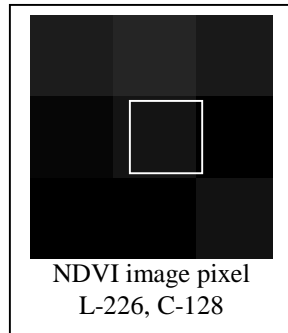
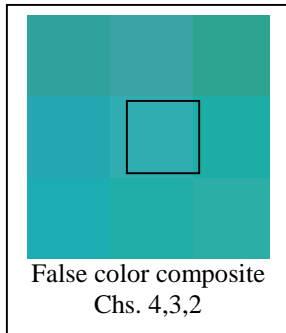
The image data value for this calculation is 123 since all calculations are multiplied by 255 for display purposes. The reason is that the software uses a 0-255 grayscale. In order to display the NDVI image the NDVI value for each pixel needs to be multiplied by 255 to spread the NDVI pixel values over the entire grayscale range. If the MultiSpec NDVI pixel has a value of 123 the true NDVI value would be 0.48 because $123 / 255 = 0.48$.

Urban/Residential land cover pixel
QASJUL97 Multispectral Image Data Values

Line	Col	Blue (Ch1)	Green (Ch2)	Red (Ch3)	NIR (Ch4)	MIR (Ch5)	Thermal (Ch6)	MIR (Ch7)
226	128	147	59	72	87	132	143	68

97 NDVI Multispectral Image Data Values

Line	Col	NDVI value (Ch 1)
226	128	$0.09 * 255 = 22.95 \Rightarrow 23$



If the same process is applied using the above urban/residential data, it is possible to see how to mathematically separate vegetative land cover from nonvegetative land cover. If the above pixels' data values are entered into the NDVI equation the resulting math occurs:

$$\frac{\text{near IR band} - \text{red band}}{\text{near IR band} + \text{red band}} = \text{NDVI} \quad \text{or} \quad \frac{\text{channel 4} - \text{channel 3}}{\text{channel 4} + \text{channel 3}} = \text{NDVI}$$

$$\frac{4 - 3}{4 + 3} = \text{NDVI} \rightarrow \frac{87 - 72}{87 + 72} = \text{NDVI} \rightarrow \frac{15}{159} = 0.09 \text{ (which is the NDVI value)}$$

By comparing these two pixel NDVI values it is possible to see mathematically why the NDVI equation is able to separate or "classify" land cover by how much photosynthesis is occurring. If a pixel has a great contrast between the near infrared (NIR) and the red channels and the NIR is the higher of the two, then the NDVI value will be high. Conversely, if the contrast is low between the NIR and the red channels then the NDVI value will be low.

Time

- 1-2 class periods to create the needed images.
- Time out of class can be used for the data analysis.
- Additional time will be necessary for the advanced level to understand how light reflectance works and possibly conduct a radiometer lab using plant reflectance

Level

Intermediate and Advanced

Key Concepts

Communication skills

Read and understand images produced by others

Produce images for other to interpret

Find and describe locations on maps and computer-generated images

Technology/Software Mastery

- Use computer software to generate images
- Use computer software to scale images
- Use computer software to interpret images

Computation and Estimation

- Use simple algebraic formulas
- Use, interpret, and compare numbers
- Estimate distances from maps and actual sizes of objects from scale drawings
- Decide what degree of precision is adequate

Critical-Response

- Be aware that there may be more than one good way to interpret a given set of findings

Skills

- Identifying* images
- Managing* time
- Collecting* data
- Integrating* information
- Analyzing* data
- Interpreting* data
- Drawing* conclusions
- Using* computers

Materials and Tools

- [MultiSpec software](#) (latest version)
- Georeferenced [Landsat images](#), a current and past image
- Color printer
- Notepaper

Teacher Preparation

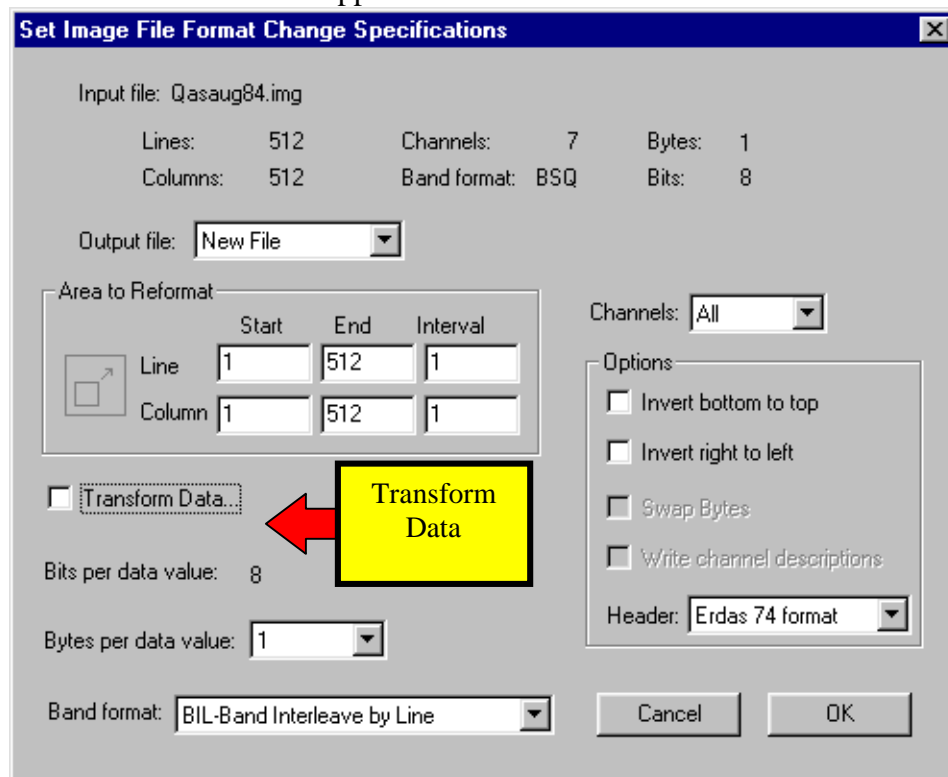
- Download the appropriate version of [MultiSpec](#)© from their web site if you do not already have a version.
- To conduct this activity with the provided data sets:**
 - Download [1984.lan](#)
 - Download [1997.lan](#)
- To conduct this activity with your school's data** obtain an older Landsat image that is georeferenced to the current image. The older the image the greater the difference will be. If at all possible a 10-year difference will give some significant results. (Note: the GLOBE program will be providing georeferenced Landsat image sets to teachers who have been trained by the GLOBE program. Follow the link to become a [GLOBE](#) teacher.)
- Complete the NDVI calculations on your version of MultiSpec© prior to the lesson to make sure any slight difference in the software doesn't interfere with the lessons
- If time constraints are an issue you can download the created NDVI images already created.

- Download [84 NDVI](#)
- Download [97 NDVI](#)

Normalized Difference Vegetation Index (NDVI) calculation

Step by step process to calculate NDVI

- Open MultiSpec©
 - Open the image to be converted into a NDVI image. **QASAUG84.img** or **QASJUL97.img**
 - Select the processor function from the top title bar
 - Select the reformat function from the pull down menu
 - The Reformatting Utilities window will appear; the default option should be “Change Image File Format.” Select the circle if it is not selected and click OK
 - The “Set Image File Format Change Specifications” window will appear. Select the “Transform Data...” box. Automatically the “Set Reformat Transform Parameters” window will appear.



- Select the “New Channel from General Algebraic Transformation” button.
- Below the “New Channel from General Algebraic Transformation” button a workspace will appear.

Set Reformat Transform Parameters

☐ Adjust Selected Channels

☒ New Channel from General Algebraic Transformation

= + *

☐ No Transformation to be Done

Cancel OK

- Change the default formula shown above to the following formula: type
in
$$0 + \frac{C4 - C3}{C4 + C3} \times 255$$

Set Reformat Transform Parameters

☐ Adjust Selected Channels

☒ New Channel from General Algebraic Transformation

= + *

☐ No Transformation to be Done

Cancel OK

- Click OK when it is complete
- Click OK on the “Set Image File Format Change Specifications” window
- Save the image.
- MultiSpec© will now create the image; the percent of completed job should be shown in a Status window.
- Once created, NDVI image needs to be opened. The “Set Display Specifications for:” should be set to 3-channel color from the pull down menu. Then click OK.

Set Display Specifications for:

test trash2

Area to Display

	Start	End	Interval
Line	1	512	1
Column	1	512	1

Display

Type: 1-Channel Color

Magnification: 1-Channel Color
2-Channel Color (R-G)
2-Channel Color (G-B)
2-Channel Color (R-B)
3-Channel Color
Side by Side Channels

Enhancement

Bits of color: 2

Stretch: Linear Stretch

Min-maxes: 2 Percent Tails Clipped

Treat '0' as: Data

Display levels per channel: 256

Channels

Gray: 1

Descriptions...

☐ Load New Histogram

Cancel OK

- The “Set Histogram Specifications” window will appear to compute a new histogram or the statistics used to display the image. Make sure the interval is set to 1 and not 15 for both the lines and columns. Click OK.
- Once the histogram is created, it will not need to be recreated. The histogram description is recorded in the text window; it can be saved along with the image for future information. The algebraic formula and the highest and lowest calculated values will be displayed.
- Under the file function of the top title bar the function “Save Text Output As...” will allow you to save the information for future review.